



## Scaling through pair-wise comparison method in required characteristics of students applying for post graduate programs

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### Abstract

**The Aim and Significance of the Research:** The characteristics that lecturers wish students applying for post-graduate programs should possess are determined in this paper quantitatively through pairwise comparisons according to the lecturers' responses.

The fact that resources and studies concerning the issue of scaling are scarcely available has been the most significant driving force for researchers to conduct research on this issue. It is believed that this research will make contributions to the field of scaling, which has limited number of studies. Since this research is a work of scaling which is rarely seen in the field of education, it is thought that the research is significant.

**Method of Research:** The research was conducted on the 129 lecturers working in the different departments of Hacettepe University in the fall and spring semesters in the 2006 – 2007 academic year. At the stage of preparing the tool of measurement, the 7 characteristics that were required students should possess for selection to post-graduate education programs were determined and a tool of measurement through which pairwise comparisons would be made were designed. Consequently, the scale value for each characteristic was marked on the line of numbers.

**Findings and Comments:** According to the pairwise comparison, academic achievement score is in the first order. This is followed by the score gained in the interview, the purpose in entering the department, their level of English proficiency, ALES score, whether or not they are originally the students of the department and whether or not they have a letter of reference, respectively. According to results, when the students are selected to the post-graduate education programs it is suggested that the weighting of the students' characteristics required is made by considering this order. In addition to this, it is thought that studying with different samples and different scaling methods provide important contribution to the field.

**Key words:** Pair-wise comparison method, scaling.

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## **Lisansüstü eğitime başvuran öğrencilerde aranan özelliklerin ikili karşılaştırma yöntemiyle ölçeklenmesi**

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### **Özet**

Bu çalışmada öğretim elemanlarının lisansüstü eğitime başvuran öğrencilerde bulunmasını istedikleri özelliklerin neler olması gerektiği, öğretim elemanlarının verdikleri tepkilere dayalı olarak nicel bir yöntem olan ikili karşılaştırmayla ölçekleme yöntemi kullanılarak belirlenmeye çalışılmıştır.

Ülkemizde ve yurtdışında ölçekleme alanında kaynakların ve ölçekleme alanında yapılmış çalışmaların sınırlı sayıda, hatta yok denecek kadar az olması, araştırmacıları bu alanda çalışma yapmaya yönlendiren en önemli unsur olmuştur. Çalışmanın bu açıdan, sınırlı sayıda yer alan ölçekleme çalışmalarına katkı getireceği düşünülmektedir. Araştırmanın eğitim alanında çok rastlamadığımız bir ölçekleme çalışması olması nedeniyle önemli olduğu düşünülmektedir.

Araştırma, 2006-2007 öğretim yılı güz ve bahar dönemlerinde Hacettepe Üniversitesi'nin farklı bölümlerinde görev yapan 129 öğretim elemanı üzerinde yürütülmüştür. Araştırmacılar tarafından lisansüstü eğitime öğrenci seçilirken aranan 7 özellik belirlenmiş ve hazırlanan ölçme aracı ile ikili karşılaştırma yapılarak her bir özelliğin ölçek değeri sayı doğrusu üzerinde belirlenmiştir.

Lisansüstü eğitime başvuran öğrencilerde bulunması istenilen özellikleri en çok istenilen özellikten en az istenilen özelliğe doğru bir sıralama yapıldığında; akademik başarı puanının ilk sırada yer aldığı belirlenmiştir. Bu özelliği sırasıyla mülakat puanı, programa girme amacı, İngilizce yeterlik puanı, ALES puanı, bölüm öğrencisi olup olmaması ve bu nitelikleri en son sırayla referansı olup olmaması özelliğinin izlediği belirlenmiştir. Bu araştırma bulgularına göre, lisansüstü eğitime öğrenci seçilirken aranan özelliklerde bu sıralamanın dikkate alınarak ağırlıklandırmanın yapılması önerilebilir. Ayrıca farklı örneklem gruplarında farklı ölçekleme yöntemleri ile çalışılmasının da alana önemli katkılar sağlayacağı düşünülmektedir.

**Anahtar sözcükler:** İkili karşılaştırma yöntemi, ölçekleme.

## Introduction

The physical properties of the most variables in behavioral sciences are not known and their physical dimensions are not available. However, many psychological structures such as intelligence, personality, attitudes, and anxieties are undeniable facts which are demonstrated via behaviors; moreover, science deals with facts. Thus, the view that psychology is unlikely to be a science because the basic data of psychology cannot be observed and measured suggested by Kant is no longer valid (Nunnally, 1970). Our feelings cannot be measured directly since they are subjective, cannot be observed by others and not be directly measurable. Feelings become observable and measurable only when they are demonstrated through behaviors. Psychology, as a positivist science, tries to do this. The aim of scientific efforts is to test the explanations of the world of visible actions. Therefore, prior to regarding an explanation as true or false, evidence should be presented through observable events. The most basic criterion for science is “observability” (Karakaş, 1988).

Psycho-physical study, which has established the scaling techniques, is a science attempting at determining the relations between the measurable qualities and the perceivable quantities of physical stimuli. Psycho-physicians consider responses as the indication of an individual’s characteristics, which don’t change from person to person but which change according to the type of stimuli. The stimulus based scaling techniques, which we call “judgment approach” in measurement, are the greatest contribution to psychometric made by psycho-physicians (Stevens, 1966).

S.S Stevens (1966) describes scaling as marking objects with numbers according to a rule. What does this mean? Objects represent themes in most of scaling; where the representations are usually attitudes or beliefs. Stevens (1966) states that scaling is used sometimes to test hypotheses, and sometimes to determine whether a case is single dimensional or multidimensional. According to Stevens, the most widely known reason for employing scaling is scoring.

The experimental methods used in scaling can be divided into two approaches that are adopted on the basis of the problem. The experimental methods in the first group are the methods known as “stimulus based approach” or “judgment approach”. The ones in the second group are the methods that are based on subjects’ responses, which are labeled as “response approach”, briefly.

Judgment approach is based on scaling the available stimuli according to observers' or experts' judgments in a dimension determined beforehand. In experimental methods, N numbers of observers each are asked to determine the stimulation degree of each of the K number of stimulants. The observers' duty is to state the size of each stimulant with regard to scaling according to other stimulants. The average value of observer judgments for a stimulant is regarded as the scale value. Typical examples of this approach can be found in scaling that is performed through Thurstone methods.

In response approach, K numbers of stimulant are applied on a group composing N number of subjects, and thus their responses are gathered. The responding individuals play the role of subjects who give their responses rather than the role of neutral experts in this approach. Therefore, the subjects' duty is not to determine the place of stimulants in the scaling dimension impartially, but to determine the place of each stimulant in the scaling dimension according to its own position in the same dimension. A typical example of response approach can be seen in the process of developing an attitude scale through Likert method.

Pairwise comparisons method which is one of the scaling methods in psychology developed by Thurstone (1927a) was used by psychologists to evaluate psychological phenomena in the late 1920s (Guilford, 1928, 1954). Although this has been labeled as “the law of pairwise comparisons” since the time of Thurstone, it would now be more appropriate to see it as a statistical model rather than a law (Turgut and Baykul, 1992). The process of the pairwise comparison is that the selection of the one in a pair of products or objects which one is more appropriate or more preferable according to characteristic which is determined (Lawless and Heymann, 1998). Where the sensory perception (especially if there is not any reference, objective choice or trained panel) cannot be rated directly, pairwise comparison methods provide useful alternative (Corcoux, Chaunier, Valle, Lourdin and Semenou, 2005).

In scaling through pairwise comparisons, the axis on which stimulants are arranged according to physical size is called physical dimension whereas the axis on which stimulants are arranged according to the perceived size is called psychological dimension. The term psychological dimension can also be stated as the scaling dimension. This dimension is determined with the stimulants' feature to be scaled.

Thurstone (1927b) defines the concept which is stated as “discriminal process” as the process in which an individual perceives, recognizes, discriminates, or responds to stimulants. In general, discrimination process is supposed to be present in the stimulants’ features which are to be scaled. At the end of the process, individuals match a stimulant with a point in the scaling dimension, which expresses the discriminating statement.

From what has been presented it becomes clear that two spaces are available; namely: the “psychological space” where the features to be scaled are located, and the “scaling space” where the perceived size of these is located. The space of features to be scaled is the space where dimensions and features are not known while the space of the perceived sizes is the space which is determined by the perceived sizes of the features.

It is assumed that when a stimulant is observed by an observer, the observer gives a stimulus which will be useful to distinguish his/her own stimulant from all others. Based on the stimulant, the observer goes through the process of discriminating, and at the end of the process s/he gives response. The response given by the observer is in the form of reaching a conclusion about the stimulant and thus representing it with a point or stating it with a value according to his/her perception. The space where those points or the corresponding values are located is the “measuring space”. When the scaling space is one dimensional, the term “scaling dimension” can also be used instead of the term “scaling space”.

Pairwise comparisons method has a wide range of application fields since respondents use the stimulants in every case where they can evaluate them in pairs. It has been used especially in the scaling of much behavior in affective domain, and also in determining some of the individuals’ personality traits. For instance it could be employed in such fields as scaling individuals’ attitudes towards certain brands or even certain food and drinks, or determining preference or aptitude of the consumers in the politic and economic fields, or collecting data about patients in the medical science (Lin JC, Lee KC, Lin LC and Lin YJ, 20007; Corcoux, Chaunier, Valle, Lourdin and Semenou, 2005; Watson, Horn, Wilson, Shiel and McLellan, 1997; USDA, 1997; Neuman, 1993; O’Neil and Chissom, 1993). Pairwise comparisons method was also known as two alternative forced choices (2-AFC) in the literature (Corcoux, Chaunier, Valle, Lourdin and Semenou, 2005).

In the literature, different methods from the method in this study can be observed for using pairwise comparisons. Eyes examination for glass is one of the most common situation in which pairwise comparison carried out. The doctor wants to s/he looks at an eye chart

through a number of different lenses. The aim of this examination is to obtain “which of the lenses is better to you for seeing the eye chart?” The doctor switches the lenses until s/he tell the doctor which one is better for seeing. Then the doctor continues another set of lenses and repeats the process until the best lenses are found (USDA, 1997). For another example; different objects which are wanted to select or compare, e.g. seven products which are labeled a number from 0 to 6, are asked to compare in different order (0123456036251405316420). Then it is wanted that every product is compared with previous one and is selected one from the pair. After the comparison of 7 successive pairs, any particular time break was recommended. The order of the products is determined by completely randomization (Corcoux, Chaunier, Valle, Lourdin and Semenou, 2005).

In our country, in the educational science, there are limited numbers of studies related to pairwise comparison method. Most of these studies are observed in developing a scale. When the scale is developed for deciding which item is more appropriate based on subjects' responses the pairwise comparison method can be preferred (Tezbaşaran, 2004; Bindak2005). Kan (2008) intended to compare two different pairwise scaling methods based on “judgment decision”. The result of the study showed that the correlation with the values obtained from two different scales is 0.20 and these two different scales do not generates same results. Öğretmen (2008) purposed to scale field preference inventory and studied reliability and validity of the scale. According to the results of the scale based on the fifth posture of Thurstone's comparative judgment law, inventory is determined as a reliable and validity measurement tool for determining the most preferable field to teach among the students at the education faculty of universities. Anıl and Güler (2006) studied what “required characteristics of a skilled teacher” should be by scaling with pairwise comparison method. According to the results, it was determined that the most desired characteristic was “love of job” and this characteristic was followed by being able to transfer knowledge, being able to communicate effectively, respectively. And the least desired characteristic was determined as being witty. Nartgün (2006) intended to define which teaching vocational knowledge course is most important for the senior students at the division of elementary teaching by using pairwise comparison method.

Scaling is a field of scientific study which aims at establishing the basic rules and major methods of “transition from observations to measures”. When considered from this perspective, scaling forms the most significant step of progressing from observations stating

qualitative discriminations into measures stating quantitative discriminations in the process of measuring. The fact that resources and studies concerning the issue of scaling are scarcely available has been the most significant driving force for researchers to conduct research on this issue. It is believed that this research will make contributions to the field of scaling, which has limited number of studies.

The characteristics that university lecturers wish students applying for post-graduate programs should possess are determined in this paper quantitatively through pairwise comparisons according to the lecturers' responses. Since the scaling study by pairwise comparison is rarely seen, it is thought that this study can provide significant contribution to the field of education.

## **Method**

### ***Type of Research***

This study required that university lecturers scale the characteristics which they wished students applying for post-graduate programs should possess by performing pairwise comparisons. Since the aim was not to make generalizations from the sample data to the population, this is just a basic research paper.

### ***The Group of Research***

The research was conducted on the 129 lecturers working in the different departments of Hacettepe University in the fall and spring semesters in the 2006 – 2007 academic year.

### ***Preparing the Tool of Measurement***

At the stage of preparing the tool of measurement, the 7 characteristics that were required students should possess for selection to the post-graduate education programs were determined; and a tool of measurement through which pairwise comparisons would be made were designed.



### ***The Analysis of the Data***

Each lecturer was asked to list the 7 characteristics that they demanded students applying for post-graduate programs should possess by making pairwise comparisons, and the frequency values for each characteristic were determined. The frequency matrix was formed in consequence of the pairwise comparisons scale. Then, rates matrix was found by dividing the value in each cell of the frequency matrix (F) into the total number of persons (N). Afterwards, standard values (Z) corresponding to the cell values in the rates matrix were identified, and unit normal deviations matrix was derived. At the end of the matrix, a line showing the total values of each column was formed; the averages of each Z cell value in this line were calculated across the columns, and the scale values were found. The beginning of the axis (the 0 point) was slid to the smallest of the average z values in this line, and the scale values (S) were arranged. If the smallest value is negative in this sliding, the absolute value of this value is added to all the values. When the smallest value is positive, this value is subtracted from all the values. In consequence, the scale value of each characteristic is identified on the line of numbers.

### **Results and Comments**

In this research, university lecturers were requested to scale the characteristics that they demanded students applying for post-graduate programs should possess through pairwise comparisons, and the phases of scaling were tabulated.

The lecturers were first asked to order the 7 characteristics by making pairwise comparisons, and the frequency values for each characteristic were determined. Consequently, frequency matrix was formed as shown in Table 1. Elements in each cell of Table 1 are represented with  $f_{ij}$ , and for this purpose, the frequencies generating the  $S_j > S_i$  value are shown. This matrix is called the matrix of frequencies (F). The matrix is symmetrical according to the original diagonal, and the total of symmetrical elements lead to the total number of observers, which is 129. What is worth noting here is that the elements on the original diagonal are not written as a stimulant cannot be compared with itself.



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Table 1

*Frequency Matrix*

F MATRIX							
Stimulant	1	2	3	4	5	6	7
1 ALES Score	<b>1,00</b>	67,00	47,00	84,00	22,00	51,00	107,00
2 Interview Score	62,00	<b>1,00</b>	83,00	99,00	53,00	74,00	112,00
3 English Proficiency	82,00	46,00	<b>1,00</b>	101,00	33,00	43,00	109,00
4 The Student of the Department	45,00	30,00	28,00	<b>1,00</b>	12,00	19,00	78,00
5 Academic Achievement Score	107,00	76,00	96,00	117,00	<b>1,00</b>	76,00	107,00
6 Purpose in Entering the Department	78,00	55,00	86,00	110,00	53,00	<b>1,00</b>	<b>100,00</b>
7 Reference	22,00	17,00	20,00	51,00	22,00	29,00	1,00

In the next stage, the value in each cell of the frequency matrix (F) was divided into the total number of persons (N), and thus the rates matrix shown in Table 2 was derived. The elements of this matrix were determined by dividing the elements of the frequency matrix in Table 1 into 129 (the number of observers, N = 129). Hence, rates matrix (P) was calculated. The total of symmetrical elements is 1.

Table 2

*Proportion Matrix*

P MATRIX							
Stimulant	1	2	3	4	5	6	7
1	<b>0</b>	0,52	0,36	0,65	0,17	0,40	0,83
2	0,48	<b>0</b>	0,64	0,77	0,41	0,57	0,87
3	0,64	0,36	<b>0</b>	0,78	0,26	0,33	0,84
4	0,35	0,23	0,22	<b>0</b>	0,09	0,15	0,60
5	0,83	0,59	0,74	0,91	0	0,59	0,83
6	0,60	0,43	0,67	0,85	0,41	<b>0</b>	0,78
7	0,17	0,13	0,16	0,40	0,17	0,22	<b>0</b>

Next, standard values (Z) corresponding to the cell values in the proportions matrix (P) were identified, and unit normal deviations matrix in Table 3 was derived. The z values of unit normal distribution corresponding to each element of the rates matrix in Table 2 were written in this table. This matrix is called unit normal deviations matrix (Z). Here the elements opposite marks according to the original diagonal and are equal in absolute value. At the end of the matrix, a line showing the total values of each column was formed; the averages of each Z cell value in this line were calculated across the columns, and the scale

values were found. In other words, the number of elements the columns was divided into 6. The total in this line is zero.

Table 3

*Unit Normal Deviations Matrix*

Z MATRIX							
Stimulant	1	2	3	4	5	6	7
1		0,05	-0,35	0,39	-0,95	-0,27	0,95
2	-0,05		0,37	0,73	-0,23	0,19	1,12
3	0,35	-0,37		0,78	-0,66	-0,43	1,02
4	-0,39	-0,73	-0,78		-1,32	-1,05	0,27
5	0,95	0,23	0,66	1,32		0,23	0,95
6	0,27	-0,19	0,43	1,05	-0,23		0,76
7	-0,95	-1,12	-1,02	-0,27	-0,95	-0,76	
Sum	0,1752	-2,1278	-0,6895	4,0062	-4,3334	-2,0893	5,0586
S(j)	0,0250	-0,3546	-0,1149	0,6677	-0,7222	-0,3482	0,8431
S(j)	0,7472	0,3676	0,6073	1,3899	0,0000	0,3740	1,5653

As can be noticed in Table 4, the beginning point (0 point) of the axis was slid to -0.72, one of the smallest average z values, and scale values were arranged; then the scale value of each characteristic was determined on the line of numbers in figure 1 by adding 0,72, the absolute value of the smallest value, to each scale value.

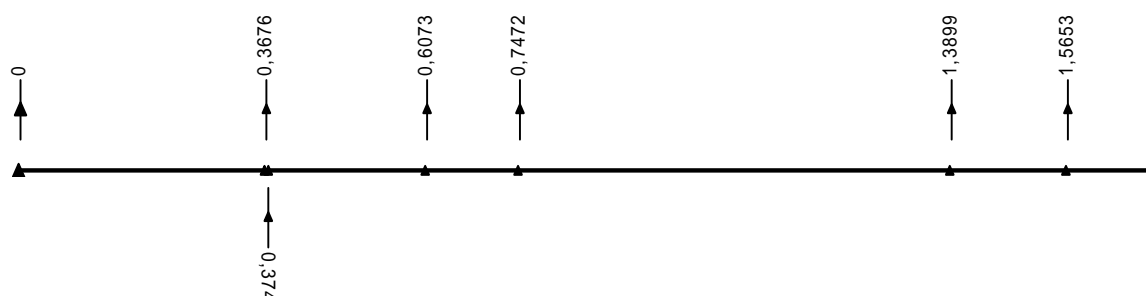
Table 4

*Scaling Values of Characteristics*

S(j)	0,0250	-0,3546	-0,1149	0,6677	-0,7222	-0,3482	0,8431
S(j)	0,7472	0,3676	0,6073	1,3899	0	0,3740	1,5653

Figure 1

*Scaling Values of Characteristics on Line of Numbers*



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According to the stimulant values that are obtained from Table 4, the characteristics that the lecturers demanded students applying for post-graduate programs should possess were ordered as shown in Table 5.

Table 5

*Scaling values and stimulant order of the lecturers demanded students applying for post-graduate programs*

Characteristics	Scaling Values	Stimulant Order
ALES Score	0,7472	1
Interview Score	0,3676	2
English Proficiency	0,6073	3
The Student of the Department	1,3899	4
Academic Achievement Score	0	5
Purpose in Entering the Department	0,3740	6
Reference	1,5653	7

Table 6

*Scaling values which are ordered and stimulant order of the lecturers demanded students applying for post-graduate programs*

Characteristics	Scaling Values	Stimulant Order
Academic Achievement Score	0	5
Interview Score	0,3676	2
Purpose in Entering the Department	0,3740	4
English Proficiency	0,6073	6
ALES Score	0,7472	1
The Student of the Department	1,3899	3
Reference	1,5653	7

On examining Table 6, which orders the characteristics that students applying for post-graduate programs should possess from the most wanted to the least wanted, we see that academic achievement score is in the first order. This is followed by the score gained in the interview, the purpose in entering the department, their level of English proficiency, ALES score, whether or not they are originally the students of the department and whether or not they have a letter of reference, respectively.

## Conclusions

In this research, university lecturers were asked to scale the characteristics that they demanded students applying for post-graduate programs should possess through pairwise comparisons. The research was conducted on the 129 lecturers working in the various departments of Hacettepe University in the fall and spring semesters in the 2006 – 2007 academic year. Each lecturer was requested to order the 7 characteristics that they preferred students applying for post-graduate programs to possess by using the pairwise comparisons method. Then, considering the ordering, the frequency values for each characteristic were calculated. Consequently, the frequency matrix was formed. Later, rates matrix was found by dividing the value in each cell of the frequency matrix (F) into the total number of persons (N). After that, unit normal deviations matrix was derived by determining standard values (Z) corresponding to the cell values in the rates matrix. At the end of the matrix, a line showing the total values of each column was formed; the averages of each Z cell value in this line were calculated across the columns, and the scale values were found. The beginning of the axis (the zero point) was slid to the smallest of the average z values in this line and scale values (S) were ordered. Consequently, the scale value for each characteristic was marked on the line of numbers.

According to the ordering, academic achievement score is in the first order. This is followed by the score gained in the interview, the purpose in entering the department, their level of English proficiency, ALES score, whether or not they are originally the students of the department and whether or not they have a letter of reference, respectively.

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